Novel Compliant Mechanisms Could Simpli

Professor Kikuchi

Professor Kota

"This research provides the opportunity to remove all moving parts from flight surfaces."

Researchers at the University of Michigan have developed a method to design single-piece, jointless mechanisms that may improve aircraft performance and simplify their design.

These devices, called compliant mechanisms, would allow the design of aircraft wings without control surfaces. This design modification provides the following benefits:

- reduces radar cross-section thereby improving stealth characteristics;
- reduces weight and complexity; and,
- increases aircraft maneuverability.

These monolithic structures are also very suitable for microelectromechanical systems (MEMS), which are critical to many next-generation U.S. Air Force weapon systems. Impressed by the potential of compliant mechanisms, the Air Force Research Laboratory's Air Vehicles Directorate has decided to continue development of the technology through the Small Business Innovation Research (SBIR) Program.

Professors Sridhar Kota's and Noboro Kikuchi's work is opening previously unachievable design possibilities. An aircraft wing based on a compliant mechanism would bend and twist as a single piece to control flight, eliminating separate control surfaces such as ailerons, spoilers, and flaps. This, in turn, simplifies construction and yields potentially much higher performance.

Compliant (flexible) structures thrive in nature. A blade of grass and certain cell membranes are good examples. Traditionally, however, engineered mechanisms tend to be strong and stiff, or non-compliant. This trend continues in current "smart" systems design. These systems rely on many smaller, rigid mechanisms and actuators that only simulate a compliant structure. However, if the underlying structure of smart systems were compliant, the resulting system would have vastly fewer jointed parts. This offers many benefits, including:

- simplified manufacturing (decreasing time and costs);
- easier and less system maintenance;
- more robust systems (fewer parts); and,
- lighter weight.

To be successful, compliant structures must offer the desired actuation characteristics and mechanical advantage but retain enough stiffness to resist external loads. These requirements led Dr. Kota, Dr. Kikuchi, and their students to develop a fundamentally new mathematical approach. It develops solutions based on prescribed boundary conditions and loading environments, and considers the kinematic, geometric, and continuum mechanics aspects of the problem. The researchers have created a finite-element, preprocessing program that quickly optimizes the cross-sectional shapes of various topologies.

Compliant mechanisms may lead to...

more maneuverable aircraft

better stealth characteristics

simplified construction

For a detailed technical explanation, please visit http://www-personal.engin.umich.edu/~kota.

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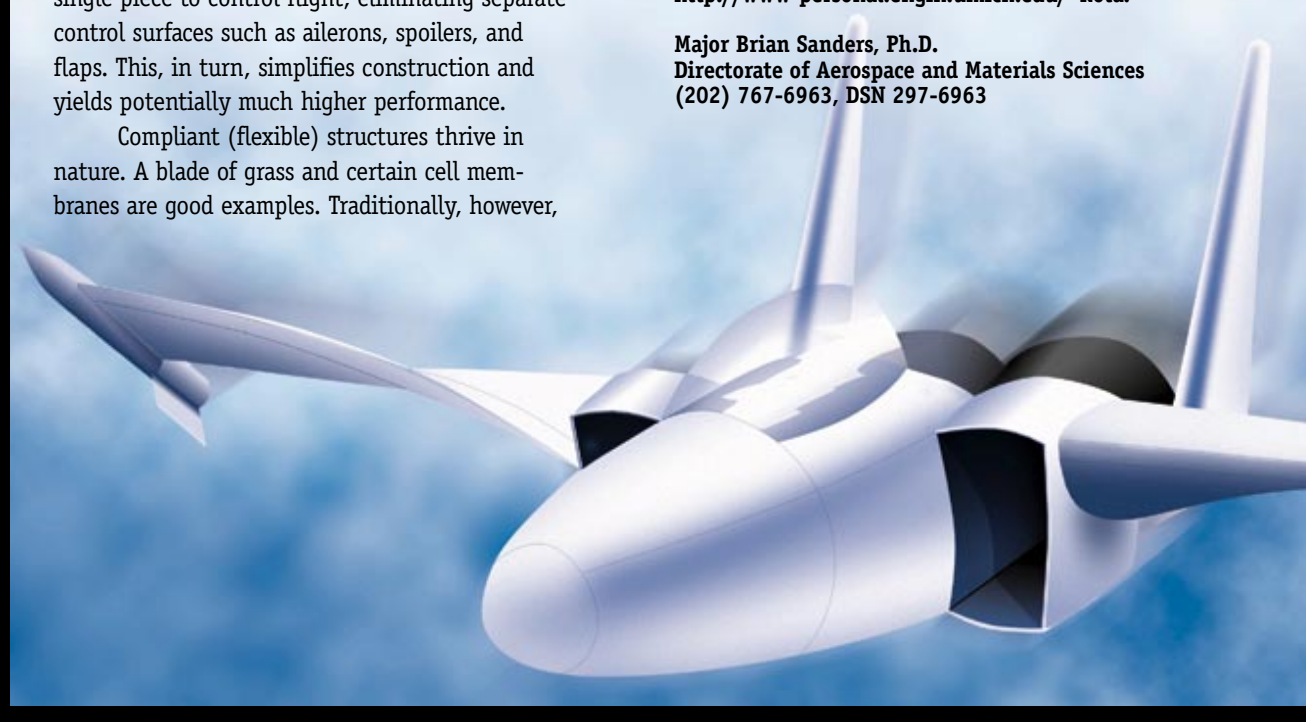

Aeroelastic Wing

RIGHT: The rendering at right represents a conceptual aircraft that uses compliant mechanisms to adapt the wing shape to improve aerodynamic performance. Current research programs to accomplish similar objectives are using external control surfaces such as leading and trailing edge flaps and other smart structures technology.